TITLE OF THE INVENTION

INK JET HEAD AND INK JET PRINTER

CROSS REFERENCE TO RELATED APPLICATION

The present application is based on Japanese Priority Document JP2002-353233 filed on December 5, 2003 the content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to an ink jet head and an ink jet printer performing an image formation by ejecting an ink droplet.

DISCUSSION OF THE BACKGROUND

In a conventional technique, a shear mode ink jet head has been well-known as disclosed in U.SP No. 4,879,568 wherein a capacity in a pressure chamber is varied by pressure means that produces a shear strain in accordance with an electrical signal for selectively ejecting ink from an ejecting nozzle provided at each pressure chamber, thereby performing an image formation. This type of shear mode ink jet head has a characteristic that the pressure chamber is easy to be arranged with high density.

However, the above-mentioned shear mode ink jet head has a problem that a phenomena so-called crosstalk occurs in which

a pressure fluctuation in some pressure chamber gives a fluctuation in a pressure or a flow velocity of the ink in the other nearby pressure chamber. It is considered that the crosstalk occurs because the pressure of the ink in the pressure chamber displaces a partitioning wall between the pressure chambers to thereby change the ink pressure in the adjacent and nearby pressure chambers.

Pressure chambers at the side of both ends within a printing range receive the crosstalk from only the other pressure chambers positioned at the inside within the printing range, while the pressure chambers positioned at the inside of the printing range receive the crosstalk from the other pressure chambers positioned at both sides. Therefore, the influence by the crosstalk is different between the pressure chambers positioned at both sides within the printing range and the pressure chambers positioned at the inside thereof. This leads to a difference between a volume of the ink droplet ejected from an ejecting nozzle communicating with the pressure chambers positioned at both sides within the printing range and a volume of an ink droplet ejected from an ejecting nozzle communicating with the pressure chambers positioned at the inside of the printing range, thereby being likely to cause a non-uniform density or a deterioration in image quality in a printed matter.

There is an ink jet head of Fig. 13 disclosed in, for example, Japanese Unexamined Patent Application No. 2000-135987 as an

ink jet head aiming to establish an equalization of the influence of the crosstalk exerted on each pressure chamber. The ink jet head shown in Fig. 13 has three dummy pressure chambers 102 formed respectively at both sides of plural pressure chambers 101 arranged in a printing range, each pressure chamber 101 having a single ejecting nozzle 103 communicating therewith and each dummy pressure chamber 102 having plural dummy nozzles 104 communicating therewith. The "dummy pressure chamber" means herein a pressure chamber from which ink is not ejected even if a driving signal is applied.

When, for example, an ink droplet is ejected by changing the capacity in the pressure chamber 101a positioned at the edge section within the printing range in the ink jet head shown in Fig. 13, the dummy pressure chamber 102a similarly changes its capacity simultaneous with the ejection of the ink droplet. Further, when an ink droplet is ejected by changing the capacity in the pressure chamber 101b positioned at the edge section within the printing range, the dummy pressure chamber 102b similarly changes its capacity simultaneous with the ejection of the ink droplet. Further, when an ink droplet is ejected by changing the capacity in the pressure chamber 101c positioned at the edge section within the printing range, the dummy pressure chamber 102c similarly changes its capacity simultaneous with the ejection of the ink droplet.

This enables to exert the influence of the crosstalk from

the other pressure chambers (effective pressure chamber and dummy pressure chamber) positioned at both sides on the pressure chambers 101a, 101b and 101c positioned at the edge sections within the printing range, like the other pressure chambers positioned at the inside of these pressure chambers 101a, 101b and 101c.

However, the ink jet head shown in Fig. 13 has plural dummy nozzles 104 communicating with one dummy pressure chamber 102 in order not to eject an ink droplet from the dummy nozzles 104 in case where the capacity in the dummy pressure chamber 102 is changed.

Therefore, a flow impedance of the dummy nozzle 104 for the dummy pressure chamber 102, i.e., a viscosity resistance, inertial resistance or the like of the ink produced at the dummy nozzle 104 reduces in inverse proportion to the number of the dummy nozzle 104. As a result, a main acoustic resonance frequency of the ink in the dummy pressure chamber 102 differs from that of the ink in the pressure chamber 101.

The main acoustic resonance frequency is a frequency in which, when the pressure chamber is driven by applying voltage with the pressure means, a pressure wave occurring in the ink in the pressure chamber is transmitted through the ink in the pressure chamber and is overlapped to thereby become the greatest pressure vibration. This frequency is called a Helmholtz resonance frequency.

Therefore, when a driving signal having a waveform matched to the acoustic resonance frequency of the ink in the effective pressure chamber 101 is applied to the ink in the dummy pressure chamber 102, an extraordinary pressure fluctuation occurs in the dummy pressure chamber 102, whereby the crosstalk caused by the extraordinary pressure fluctuation occurring in the dummy pressure chamber 102 is exerted on the respective three effective pressure chambers 101 positioned at both end sections within the printing range, thereby rather entailing a problem of bringing non-uniform density or deterioration in image quality depending upon the situation.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide an ink jet head and an ink jet printer capable of preventing a variation of a volume of an ink droplet ejected from each ejecting nozzle caused by a crosstalk, thereby being capable of preventing the occurrence of a non-uniform density or deterioration in image quality.

The object of the present invention can be attained by a novel ink jet head and ink jet printer of the present invention.

According to a novel ink jet head of the present invention, an ink jet head that varies a capacity in plural pressure chambers arranged in parallel, and respectively communicating with ink supplying paths, each chamber being defined by side walls,

wherein the plurality of the pressure chamber comprise a printing region and a non-printing region, thereby ejecting an ink droplet from an ejecting nozzle mounted at one end of this pressure chamber is provided with a dummy nozzle mounted at one end of the pressure chamber positioned in the non-printing region and set to have an aperture diameter at the ink ejecting side greater than an aperture diameter of the ejecting nozzle and to have a flow impedance approximately same as that of the ejecting nozzle. When the ink droplet is ejected from the ejecting nozzle communicating with the pressure chamber positioned at an end of the printing region, the capacity in the pressure chamber in the non-printing region is varied simultaneously.

Further, according to a novel inkjet printer of the present invention, the ink jet head and a recording medium are relatively moved such that the recording medium passes a print position opposite to the ejecting nozzle in the ink jet head, and pressure means and head driving means at the ink jet head are driven based upon a driving signal in accordance with image data.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the present invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a longitudinal side view showing an ink jet head of an embodiment according to the present invention;

Fig. 2 is a sectional view taken along a line A-A in Fig. 1;

Fig. 3 is an explanatory view showing a state of a capacity change in a pressure chamber due to a shearing strain;

Fig. 4 is a sectional view showing shapes of an ejecting nozzle and a dummy nozzle;

Fig. 5 is an explanatory view for explaining a process for forming the ejecting nozzle and the dummy nozzle;

Fig. 6 is an explanatory view showing a calculation model of a flow impedance of the ejecting nozzle and the dummy nozzle;

Fig. 7 is a timing chart of a driving waveform outputted to an electrode;

Fig. 8 is an explanatory view showing a detail of the driving waveform;

Fig. 9 is a sectional view showing a modified example of the ejecting nozzle and the dummy nozzle;

Fig. 10 is a perspective view showing a part of an ink jet printer according to another embodiment of the present invention;

Fig. 11 is an explanatory view showing a holding state of an ink jet head at a head holding member provided at the ink jet printer of another embodiment according to the present invention;

Fig. 12 is a block diagram showing various electric circuits provided at the ink jet printer of another embodiment of the present invention and a relationship among these electric circuits; and

Fig. 13 is a front view showing a conventional ink jet head (Prior art).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

An embodiment of the present invention will be explained with reference to Figs. 1 to 8. Fig. 1 is a longitudinal side view showing an ink jet head, while Fig. 2 is a sectional view taken along a line A-A in Fig. 1.

The ink jet head 1 in the present embodiment is provided with two piezoelectric members (lower piezoelectric member 2 and upper piezoelectric member 3) polarized in a direction of a plate thickness as shown in Figs. 1 and 2. Two piezoelectric members 2 and 3 are laminated with the same polarity opposed to each other. The laminated piezoelectric members 2 and 3 are fixed to a substrate 4 made of a non-polarized low dielectric constant piezoelectric member.

The substrate and the piezoelectric members 2 and 3 fixed to this substrate 4 have plural channels 5 arranged in parallel with the same space. The plural channels 5 are processed by using a diamond cutter or the like.

A top plate frame 6 is adhered on the top surface of the

substrate 4. This top plate frame 6 seals a part of the top surface of the channel 5, whereby pressure chambers 7 (7a, 7b, 7c .....) are formed.

The space between the adjacent pressure chambers 7 is composed of the lower piezoelectric member 2 and the upper piezoelectric member 3 and is partitioned by side walls 8 (8a, 8b, 8c, ...) that form pressure means for varying the capacity in the pressure chamber 7 in accordance with a driving signal.

The top plate frame 6 is provided with an ink supplying path 9 that communicates with all pressure chambers 7.

A top plate frame 10 is adhered onto the top surface of the top plate frame 6. This top plate 10 is provided with an ink supplying opening 11 communicating with the ink supplying path 9. Connected to the ink supplying opening 11 is an ink supplying pipe (not shown) for supplying ink to the ink jet head 1.

Provided at the inner surface of each channel 5 are electrodes 12 (12a, 12b, 12c, ...) electrically independent to one another. The electrode 12 in this embodiment is made by non-electrolysis nickel plating. Each electrode 12 is connected to a driver IC (not shown) that is driving means via a flexible cable 13 connected to the rear end section of the substrate 4.

A nozzle plate 14 made of polyimide is adhered onto the front side of the pressure chamber 7. Mounted at this nozzle

plate 14 are ejecting nozzles 15 (15e, 15f, 15g, ...) and dummy nozzles 16 (16a, 16b, 16, 16d). The ejecting nozzles 15 and the dummy nozzles 16 in this embodiment are formed by a laser processing. The laser processing of the ejecting nozzles 15 and the dummy nozzles 16 to the nozzle plate 14 is performed after the nozzle plate 14 is adhered on the front side of the pressure chamber 7.

The ejecting nozzles 15 are formed at the positions opposite to the pressure chambers 7 (7e, 7f, 7g, ...) positioned within the printing range. The dummy nozzles 16 are formed at the positions opposite to the pressure chambers 7 (7a, 7b, 7c, 7d) positioned at the outside of the printing range.

It is to be noted that Fig. 2 shows only one end section of the ink jet head 1, and formed at the other end section of the ink jet head 1 are also four pressure chambers 7 positioned at the outside of the printing range and four dummy nozzles 16 positioned so as to oppose to these pressure chambers 7.

Ink is injected through the ink supplying pipe to the ink jet head 1 from the ink supplying opening 11, and then, filled in the ink supplying path 9, pressure chambers 7, ejecting nozzles 15 and dummy nozzles 16.

When a negative driving signal is applied from the driver IC to the electrode 12e, for example, in the ink jet head 1 having the above-mentioned construction, an electric field perpendicular to the polarizing direction occurs at the side

walls 8d and 8e. The side walls 8d and 8e respectively bend in the opposite direction for increasing the capacity in the pressure chamber 7e as shown in Fig. 3 due to an inverse piezoelectric effect caused by the electric field perpendicular to the polarizing direction, thereby producing a shear strain. This increases the capacity in the pressure chamber 7e (Fig. 3(a)). Further, when a positive driving signal is applied to the electrode 12e from the driver IC, the capacity in the pressure chamber 7e is decreased on the contrary (Fig. 3(b)). As described above, applying the driving signal to the electrode 12e enables to selectively vary the capacity in the pressure chamber 7e. When the capacity in the pressure chamber 7e increases, the pressure of the ink in the pressure chamber 7e is reduced, thereby causes a pressure fluctuation starting with a negative polarity in the ink in the pressure chamber. Further, when the capacity in the pressure chamber 7e decreases, the pressure of the ink in the pressure chamber 7e is increased, thereby causes a pressure fluctuation starting with a positive polarity in the ink in the pressure chamber 7e. The ink in the pressure chamber 7e is ejected from the ejecting nozzle 15e as ink droplets when the pressure fluctuation is overlapped with each other to thereby increase the pressure of the ink in the pressure chamber 7e.

Subsequently, the dummy nozzle 16 and the ejecting nozzle 15 are explained. Fig. 4 is a sectional view showing shapes of the dummy nozzle 16 and the ejecting nozzle 15. The dummy

nozzle 16 has a shape wherein the diameter of the nozzle is widened toward the ink ejecting direction. The ejecting nozzle 15 has, contrary to the dummy nozzle 16, a shape wherein the diameter of the nozzle is narrowed toward the ink ejecting direction.

An aperture diameter Dod of the dummy nozzle 16 at the outlet side is set such that it is approximately the same as an aperture diameter Dir of the ejecting nozzle 15 at the inlet side. An aperture diameter Did of the dummy nozzle 16 at the inlet side is set such that it is approximately the same as an aperture diameter Dor of the ejecting nozzle 15 at the outlet side. The ejecting nozzle 15 and the dummy nozzle 16 are formed so as to have a symmetrical taper shape with respect to the direction in which the ink droplets are ejected.

One preferable example of sizes of the dummy nozzle 16 and the ejecting nozzle 15 is as follows:

Aperture Diameter Dod at the outlet side of the dummy nozzle 16: 54 micrometers

Aperture Diameter Did at the inlet side of the dummy nozzle 16: 27 micrometers

Aperture Diameter Dor at the outlet side of the ejecting nozzle 15: 27 micrometers

Aperture Diameter Dir at the inlet side of the ejecting nozzle 15: 54 micrometers

Length of nozzle (dummy nozzle 16, ejecting nozzle 15) Ln: 50 micrometers

In this case, the ratio of the sectional area of the dummy nozzle 16 at the outlet side to the sectional area of the ejecting nozzle 15 at the outlet side is 4 : 1 since it is in proportion to the square of each diameter. Specifically, the flow velocity of the ink in the dummy nozzle 16 is one fourth the flow velocity of the ink in the ejecting nozzle 15 at the position of an ink meniscus m. Accordingly, ink droplets are not ejected from the dummy nozzle 16 even if the pressure of the ink in the pressure chambers 7a to 7d increases.

Moreover, when the diameter at the outlet side increases like the dummy nozzle 16, force that the ink meniscus m holds its position by a surface tension of the ink is weakened, but its static negative pressure limit Ps becomes -2222Pa when calculated by using a formula (1),

$$Ps = -\frac{4\sigma}{Doi} \qquad (1)$$

wherein the surface tension (σ) of the ink is 30 mN/m.

An ink hydrostatic pressure at the nozzle surface is required to be maintained within 0 to -2222 Pa, but normally, an ink supplying pressure is adjusted to have the ink hydrostatic pressure at the nozzle surface of -1000 Pa, thus there is no problem.

Further, even if the ink hydrostatic pressure becomes instantaneously less than the negative pressure limit Ps, the nozzle diameter becomes small as the ink meniscus m retreats

in the dummy nozzle 16, to thereby increase the negative pressure limit, with the result that the force for recovering the ink meniscus m to the original position is strengthened.

Therefore, the ink meniscus m retreats to the inside of the pressure chamber 7 and an air bubble is caught in the pressure chamber 7, whereby the negative pressure limit that causes a malfunction of the ink jet head 1 is the same as that of the ejecting nozzle 15.

The above-mentioned dummy nozzle 16 and the ejecting nozzle 15 are easily formed by a processing using laser beam L. Specifically, a laser irradiating device having an imaging optical system is utilized, wherein a relative position of a laser projection lens and the nozzle plate 14 is varied depending upon xyz stage, and in case where the dummy nozzle 16 is formed, a laser converging surface is matched to the bottom surface of the nozzle plate 14 by the adjustment of the z stage as shown in Fig. 5(a), while the laser converging surface is matched to the top surface of the nozzle plate 14 by the adjustment of the z stage as shown in Fig. 5(b) in case where the ejecting nozzle 15 is formed.

The acoustic characteristics of the dummy nozzle 16 and the ejecting nozzle 15 are as follows. When the following definitions are made in the ejecting nozzle 15 in Fig. 6:

$p(t)$: ink pressure at the inlet of the nozzle

$q(t)$: ink flow rate at the inlet of the nozzle

M : inertial resistance of the ink in the nozzle

R : viscosity resistance of the ink in the nozzle

(ρ) : density of the ink

y(x): radius of the nozzle at the position x

r(y) pressure gradient due to the viscosity per unit flow rate of the ink flowing through a cylinder with a radius y

Ln : length of the nozzle

an equation of motion

$$P(t) = M\frac{d}{dt}q(t) + Rq(t) \qquad (2)$$

relating to the ink in the nozzle is established wherein

$$M = \frac{\rho}{\pi}\pi\int_0^{Ln} \frac{1}{y(x)^2}dx\ . \qquad (3)$$

It is understood from the formula (2) that the acoustic characteristic of the nozzle for the pressure chamber 7, i.e., the flow impedance is characterized by the inertial resistance M and the viscosity resistance R.

Considering here an inertial resistance M' and a viscosity resistance R' of the dummy nozzle 16 that is opposite in direction to the ejecting nozzle 15 as shown in Fig. 6, a following formula (4) is obtained.

$$R = \int_0^{Ln} r(y(x))dx \qquad (4)$$

$$M' = \frac{\rho}{\pi}\int_0^{Ln} \frac{1}{y'(x)^2}dx = \frac{\rho}{\pi}\int_0^{Ln} \frac{1}{y(Ln-x)}dx = \frac{\rho}{\pi}\int_0^{Ln} \frac{1}{y(x)}dx = M \qquad (5)$$

$$R' = \int_0^{Ln} r(y'(x))dx = \int_0^{Ln} r(y(Ln - x))dx = \int_0^{Ln} r(y(x))dx = R \qquad (6)$$

It is understood from above formulas (5) and (6) that the inertial resistances M, M' and the viscosity resistances R, R' of the ejecting nozzle 15 and the dummy nozzle 16 each having an opposite shape in direction to each other are the same, which means that the flow impedances of both nozzles are the same.

Accordingly, in case where the outlet diameter Dod of the dummy nozzle 16 is approximately the same as the inlet diameter Dir of the ejecting nozzle 15 and the inlet diameter Did of the dummy nozzle 16 is approximately the same as the outlet diameter Dor of the ejecting nozzle 15 as disclosed in the present embodiment, the dummy nozzle 16 and the ejecting nozzle 15 have approximately the same flow impedance.

This enables to make the pressure vibration characteristic of the pressure chambers 7b to 7d at the non-printing region approximately equal to the pressure vibration characteristic of the pressure chambers 7e, 7f, ... positioned within the printing range, and further enables to make the main acoustic resonance frequency of the ink in the pressure chambers 7b, 7c, ... approximately equal thereto.

Further, in case where a suction operation of the ink is performed from the ejecting nozzle 15 and the dummy nozzle 16 upon the maintenance of the ink jet head 1, more ink than necessary is made to flow from the dummy pressure chamber in the conventional

ink jet head provided with plural dummy nozzles in the dummy pressure chamber.

On the other hand, more ink than necessary is not made to flow from the dummy pressure chamber in the present embodiment since the dummy nozzle 16 and the ejecting nozzle 15 have the same viscosity resistance. This enables to reduce a waste of ink upon the maintenance.

Fig. 7 is a timing chart of a driving signal WW outputted from the driver IC to the electrode 12 in a black solid printing. The driving signal is not applied to the electrode 12a which consequently has a constant potential. Applied at all times to the electrode 12b is a potential same as that applied to the electrode 12e. Applied at all times to the electrode 12c is a potential same as that applied to the electrode 12f. Applied at all times to the electrode 12d is a potential same as that applied to the electrode 12g. Although Fig. 7 shows only one end section of the ink jet head 1, the same is applied to the other end section of the ink jet head 1.

The driving signal is time-shared in three phases. When ink is ejected from some nozzle 15, ink is not ejected from the next-door nozzles on both sides of the nozzle ejecting ink and is not ejected further from the adjacent nozzles of the next-door nozzles.

The driving signal WW is made of seven drop signals W continuously arranged. When this driving signal WW is applied

to the pressure chamber 7, one ink droplet is ejected from the ejecting nozzle 15 per one drop signal. In case where the number of the drop signal W is seven in the driving signal WW, for example, seven ink droplets are continuously ejected from the ejecting nozzle 15 for a single driving signal WW. Accordingly, if the amount of the ink droplet adhered on one pixel is intended to be changed, the number of the drop signal W in the driving signal WW may be changed. This construction can perform a printing of 8-tone including the case where ink is not ejected.

The drop signal W is made of an expanding pulse P1 for expanding the capacity of the pressure chamber 7, a contracting pulse P2 for contracting the capacity of the pressure chamber 7 and a quiescent period between both pulses. The width of the expanding pulse P1, the quiescent period and the width of the contracting pulse P2 are respectively 1AL. The AL means here a time that is half the main acoustic resonance period of the ink in the pressure chamber 7, i.e., a time for inverting the average of the pressure of the ink in the pressure chamber 7 from a positive value to a negative value or from a negative value to a positive value. The main acoustic resonance frequency that is the inverse of the main acoustic resonance period of the ink in the pressure chamber 7 is called Helmholts resonance frequency. The expanding pulse P1 ejects ink from the ejecting nozzle 15, while the contracting pulse P2 has an effect of killing the pressure vibration produced by the expanding pulse P1.

As described before, the present invention can approximately match the main acoustic resonance period of the ink in the pressure chamber 7, with which the dummy nozzle 16 is made to communicate, to the main acoustic resonance period of the ink in the pressure chamber 7 with which the ejecting nozzle 15 is made to communicate. Strictly speaking, there may be a possibility that both main acoustic resonance periods are delicately different from each other since the shape in the vicinity of the nozzle (dummy nozzle 16, ejecting nozzle 15) is different between the pressure chamber 7 with which the dummy nozzle 16 communicates and the pressure chamber 7 with which the ejecting nozzle 15 communicates. This difference hardly matters in the case of ejecting one droplet. However, in case where plural ink droplets are continuously ejected as in the present embodiment, the timing of the driving signal W may be matched to the main acoustic resonance period of the ink in the pressure chamber 4 with which the ejecting nozzle 15 is made to communicate.

In this configuration, the potentials of the electrode 12b and the electrode 12e, the potentials of the electrode 12c and the electrode 12f, the potentials of the electrode 12d and the electrode 12g are respectively the same, so that when the shear strain occurs at the partitioning walls 8d and 8e of the pressure chamber 7e, the shear strain simultaneously occurs at the side walls 8a and 8b of the pressure chamber 7b. Further,

when the shear strain occurs at the partitioning walls 8e and 8f of the pressure chamber 7f, the shear strain simultaneously occurs at the side walls 8b and 8c of the pressure chamber 7c. Additionally, when the shear strain occurs at the side walls 8f and 8g of the pressure chamber 7g, the shear strain simultaneously occurs at the side walls 8c and 8d of the pressure chamber 7d. Even if the pressure chambers 7b, 7c and 7d have the shear strain, ink is not ejected since the dummy nozzles 16b, 16c and 16d communicate with the pressure chambers 7b, 7c and 7d. However, the flow impedances of the dummy nozzle 16 and the ejecting nozzle 15 are approximately the same, with the result that the pressure vibration approximately same as that in the pressure chambers 7c, 7f, 7g ..... is produced in the pressure chambers 7b, 7c and 7d. Therefore, the amplitude of the crosstalk leaked from the pressure chambers 7b, 7c and 7d also becomes the same as the amplitude of the crosstalk leaked from the pressure chambers 7e, 7f, 7g, ... Accordingly, upon the black solid printing, the pressure chambers 7e, 7f and 7g positioned at the end of the printing region receive the crosstalk of the same amplitude from both sides like the other pressure chambers 7h, 7i, 7j, ... positioned at the inside of the printing region. Accordingly, the volume of the ink droplet ejected from the ejecting nozzles 15e, 15f and 15g can be made approximately equal to the volume of the ink droplet ejected from the ejecting nozzles 15h, 15i, 15j, ... Consequently, a non-uniform

density at the end of the printing region and deterioration in image quality can be prevented.

Although the above-mentioned embodiment makes an explanation taking as an example the ejecting nozzle 15 and the dummy nozzle 16 both having the linear taper shape in the inner peripheral surface, the inner peripheral surface of an ejecting nozzle 15A and a dummy nozzle 16A may be formed like a curved taper shape as shown in Fig. 9. In this case, the ejecting nozzle 15A and the dummy nozzle 16A are formed such that the taper shape becomes symmetrical with respect to the ink ejecting direction, thereby being capable of making the flow impedances of the ejecting nozzle 15A and the dummy nozzle 16A approximately equal as described above.

Subsequently, another embodiment of the present invention will be explained with reference to Figs. 10 to 12. It is to be noted that the same parts as the embodiment 1 are given by the same numerals for omitting the explanation thereof.

Fig. 10 is a perspective view showing a part of an ink jet printer of another embodiment according to the present invention. The ink jet printer is provided with a line ink jet head 20. The line ink jet head 1 has plural ink jet heads 1 arranged in a line and a head holding member 21 for holding these ink jet heads 1. The plural ink jet heads 1 are arranged along the arrangement direction of the ejecting nozzle and the dummy nozzle at the head holding member 21 as shown in Fig. 11. The

ink jet heads 1 are arranged alternately with respect to both surfaces of the plate-like head holding member 21. This can arrange the printing range of each ink jet head 1 along the arrangement direction of the ink jet head 1 without a space.

The ink jet printer has a sheet transporting belt 23 for transporting recording sheet 22 such that the sheet 23 passes the position opposite to the ink jet head 1 held by the head holding member 21. The sheet transporting belt 23 in the present embodiment has an endless belt shape wound around a pair of rollers 24. A driving mechanism such as a motor or the like not shown is connected to at least one of the pair of rollers 24. The sheet transporting belt 23 is rotated by rotatably driving at least one of the rollers 24 by the driving mechanism to thereby transport the recording sheet 22. Upon transporting the recording sheet 22 by the sheet transporting belt 23, the recording sheet 22 is adsorbed to the sheet transporting belt 23 by static electricity or airflow, or the edge section of the recording sheet 22 is held by a holding member not shown, so that the recording sheet 22 comes in close contact with the sheet transporting belt 23. A method for bringing the recording sheet 22 into close contact with the sheet transporting belt 23 is a well-known technique, so that its explanation is omitted.

Fig. 12 is a block diagram showing various electric circuits provided at the ink jet printer of another embodiment of the present invention and a relationship among these electric

circuits. The ink jet printer has an image memory 25 that stores image data printed on the recording sheet 22. A control circuit 26 reads the image data stored in the image memory 25 in a predetermined order when the recording sheet 22 transported by the sheet transporting belt 23 passes the position opposite to the ink jet head 1, and transmits a print signal according to the read-out image data to a driver IC 27. The driver IC 27 outputs the driving signal WW having a predetermined shape to the corresponding ink jet head 1. This enables a printing according to the number of the drop signal W or the like in each driving signal WW like the above-mentioned disclosure.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.